

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2004/003243

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 G01N 21/35

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G01N 21/00, 21/35

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Patents and applications for inventions since 1975

Korean Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKIPASS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6194735 B1 (HANS GORAN EVALD MARTIN) 27 Feb. 2001 see abstract; Figures 7-11; column 1, lines 4-52; column 7, line 27 - column 8, line 40	11-14, 16-19, 22, 24, 25 1-10, 15, 20, 21, 23
A	WO 9941592 A1 (HANS GORAN EVALD MARTIN) 19 Aug. 1999 see abstract; Figure 1; page 20, line 9 - page 22, line 11	1-25
A	US 5973326 A (MICHAEL F., CHELMSFORD & ALAN M. D., MALDON) 26 Oct. 1999. see abstract; Figure 1; column 3, line 16 - column 4, line 35	1-25
A	US 5170064 A (ATOMIC ENERGY OF CANADA LIMITED) 8 Dec. 1992 see the whole document	1-25
A	US 5116120 A (VOLKSWAGEN AG) 26 May 1992 see abstract; Figure 2; column 2, line 44 - column 14, line 9	1-25
A	US 4189236 A (COULTER ELECTRONICS, INC.) 19 Feb. 1980 see the whole document	1-25

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"Z" document member of the same patent family


Date of the actual completion of the international search

15 MARCH 2005 (15.03.2005)

Date of mailing of the international search report

16 MARCH 2005 (16.03.2005)

Name and mailing address of the ISA/KR

 Korean Intellectual Property Office
920 Dunsan-dong, Seo-gu, Daejeon 302-701,
Republic of Korea
Facsimile No. 82-42-472-7140

Authorized officer

KIM, Sang Hye

Telephone No. 82-42-481-5974



INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2004/003243

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US08194735	27.02.2001	AU199738741B2 CA2282740AA CN1228839 EP0963547A1 JP2000517055T2 SE9603109A0 US6194735BA WO9609152A1	19.03.1998 05.03.1998 15.09.1999 15.12.1999 19.12.2000 28.08.1996 27.02.2001 05.03.1998
WO9941592A1	19.08.1999	AU199926493A1 CA2320818A1 CN1297530 EP01057006A1 EP01057213A2 EP1057213A2 JP14503806 JP14503556 SE9800462A0 US6372542B1 WO9941772A2	30.08.1999 19.08.1999 30.05.2001 06.12.2000 06.12.2000 06.12.2000 05.02.2002 05.02.2002 17.02.1998 18.04.2002 19.08.1999
US05973326	26.10.1999	CA2212432AA EP625430A2 EP625430A3 GB9616809A0 US5973326A	10.02.1998 25.02.1998 19.08.1998 25.09.1996 26.10.1999
US05170064	08.12.1992	AU6291090A1 CA1318520A1 DE69007291C0 EP493401A1 EP493401B1 JP05503352 US5170064A WO9105240A1	28.04.1991 01.06.1993 14.04.1994 08.07.1992 09.03.1994 03.06.1993 08.12.1992 18.04.1991
US05116120	26.05.1992	DE4037495A1 JP6169565A2 JP2524443B2 US5116120A	20.06.1991 14.08.1994 14.08.1995 26.05.1992
US04189236	19.02.1980	CA1126977A1 DE2910030A1 FR2420752A1 FR2420752B3 GB2016734A1 JP54130186A2 US4189236A	06.07.1982 04.10.1979 19.10.1979 08.01.1982 26.09.1979 09.10.1979 19.02.1980

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)



Applicant's or agent's file reference IPN-26371.01	FOR FURTHER ACTION see Form PCT/ISA/220 as well as, where applicable, item 5 below.	
International application No. PCT/KR2004/003243	International filing date (day/month/year) 10 DECEMBER 2004 (10.12.2004)	(Earliest) Priority Date (day/month/year) 12 DECEMBER 2003 (12.12.2003)
Applicant ELT INC. et al		

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
 - a. With regard to the language, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.
☐ The international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).
 - b. ☐ With regard to any nucleotide and/or amino acid sequence disclosed in the international application, see Box No. I.
2. ☐ Certain claims were found unsearchable (See Box No. II)
3. ☐ Unity of invention is lacking (See Box No. III)
4. With regard to the title,
 - ☒ the text is approved as submitted by the applicant.
 - ☐ the text has been established by this Authority to read as follows:
5. With regard to the abstract,
 - ☒ the text is approved as submitted by the applicant.
 - ☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. With regard to the drawings,
 - a. the figure of the drawings to be published with the abstract is Figure No. 8
 - ☒ as suggested by the applicant.
 - ☐ because the applicant failed to suggest a figure.
 - ☐ because this figure better characterizes the invention.
 - b. ☐ none of the figure is to be published with the abstract.

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Korean Utility models and applications for Utility models since 1975Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 6194735 B1 (HANS GORAN EVALD MARTIN) 27 Feb. 2001 see abstract; Figures 7-11; column 1, lines 4-52; column 7, line 27 - column 8, line 40	11-14, 16-19, 22, 24, 25 1-10, 15, 20, 21, 23
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A	US 5973326 A (MICHAEL P., CHELMSFORD & ALAN M. D., MALDON) 26 Oct. 1999 see abstract; Figure 1; column 3, line 16 - column 4, line 35	1-25
A	US 5170064 A (ATOMIC ENERGY OF CANADA LIMITED) 8 Dec. 1992 see the whole document	1-25
A	US 5116120 A (VOLKSWAGEN AG) 26 May 1992 see abstract; Figure 2; column 2, line 44 - column 14, line 9	1-25
A	US 4189236 A (COULTER ELECTRONICS, INC.) 19 Feb. 1980 see the whole document	1-25

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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- "X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "Z" document member of the same patent family

Date of the actual completion of the international search

15 MARCH 2005 (15.03.2005)

Date of mailing of the international search report

16 MARCH 2005 (16.03.2005)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
920 Dunsan-dong, Seo-gu, Daejeon 302-701,
Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

KIM, Sang Hee

Telephone No. 82-42-481-5974



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2004/003243

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US06194735	27.02.2001	AU199738741B2	19.03.1998
		CA2262740AA	05.03.1998
		CN1228839	15.09.1999
		EP0963547A1	15.12.1999
		JP2000517055T2	19.12.2000
		SE9603109A0	28.08.1996
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		EP01057006A1	06.12.2000
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		JP14503806	05.02.2002
		JP14503556	05.02.2002
		SE9800462A0	17.02.1998
		US6372542B1	16.04.2002
US05973326	26.10.1999	WO9941772A2	19.08.1999
		CA2212432AA	10.02.1998
		EP825430A2	25.02.1998
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		GB9616809A0	25.09.1996
		US5973326A	26.10.1999
US05170064	08.12.1992	AU6291090A1	28.04.1991
		CA1318520A1	01.06.1993
		DE69007291C0	14.04.1994
		EP493401A1	08.07.1992
		EP493401B1	09.03.1994
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US05116120	26.05.1992	DE4037495A1	20.06.1991
		JP6169565A2	14.06.1994
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		US5116120A	26.05.1992
US04189236	19.02.1980	CA1126977A1	06.07.1982
		DE2910030A1	04.10.1979
		FR2420752A1	19.10.1979
		FR2420752B3	08.01.1982
		GB2016734A1	26.09.1979
		JP54130186A2	09.10.1979
		US4189236A	19.02.1980

PATENT COOPERATION TREATY

PCT



INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference NOP80004PCT	FOR FURTHER ACTION		See Form PCT/IPEA/416
International application No. PCT/KR2004/003243	International filing date(day/month/year) 10 DECEMBER 2004 (10.12.2004)	Priority date(day/month/year) 12 DECEMBER 2003 (12.12.2003)	
International Patent Classification (IPC) or national classification and IPC G01N 21/37(2006.01)i			
Applicant ELT INC. et al			

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 4 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
 - a. ☒ (sent to the applicant and to the International Bureau) a total of 11 sheets, as follows:
 - ☒ sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
 - ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
 - b. ☐ (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) _____ containing a sequence listing and/or tables related thereto, in electronic form only, as indicated in the Supplemental Box relating to Sequence Listing (see Section 802 of the Administrative Instructions).
4. This report contains indications relating to the following items:
 - ☒ Box No. I Basis of the report
 - ☐ Box No. II Priority
 - ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
 - ☐ Box No. IV Lack of unity of invention
 - ☒ Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
 - ☐ Box No. VI Certain documents cited
 - ☐ Box No. VII Certain defects in the international application
 - ☐ Box No. VIII Certain observations on the international application

Date of submission of the demand 12 OCTOBER 2005 (12.10.2005)	Date of completion of this report 28 MARCH 2006 (28.03.2006)
Name and mailing address of the IPEA/KR  Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer HONG, JUNG HYE Telephone No. 82-42-481-8142 

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.

PCT/KR2004/003243

Box No. 1 Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.
- ☒ This report is based on translations from the original language into the following language English which is the language of a translation furnished for the purposes of:
- ☐ international search (under Rules 12.3 and 23.1(b))
- ☒ publication of the international application (under Rule 12.4)
- ☐ international preliminary examination (under Rules 55.2 and/or 55.3)
2. With regard to the **elements** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:
- ☐ the international application as originally filed/furnished
- ☒ the description:
pages 1-3, 8-17, 20-25, 27 as originally filed/furnished
pages* 4, 6, 7, 18, 19, 26 received by this Authority on 23/11/2005
pages* _____ received by this Authority on _____
- ☒ the claims:
pages 28, 33 as originally filed/furnished
pages* _____ as amended (together with any statement) under Article 19
pages* 29, 30, 31, 31, 32 received by this Authority on 23/11/2005
pages* _____ received by this Authority on _____
- ☒ the drawings:
pages 1/29-29/29 as originally filed/furnished
pages* _____ received by this Authority on _____
pages* _____ received by this Authority on _____
- ☐ the sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.
3. ☒ The amendments have resulted in the cancellation of:
- ☒ the description, pages 5
- ☒ the claims, Nos. 18
- ☐ the drawings, sheets _____
- ☐ the sequence listing (specify): _____
- ☐ any table(s) related to sequence listing (specify): _____
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
- ☐ the description, pages _____
- ☐ the claims, Nos. _____
- ☐ the drawings, sheets _____
- ☐ the sequence listing (specify): _____
- ☐ any table(s) related to sequence listing (specify): _____

* If item 4 applies, some or all of those sheets may be marked "superseded."

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.

PCT/KR2004/003243

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-17, 19-25	YES
	Claims		NO
Inventive step (IS)	Claims	1-17, 19-25	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-17, 19-25	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

1. Prior Art

Reference is made to the following documents:

D1: US 6194735 B1 (HANS GORAN EVALD MARTIN) 27 Feb. 2001

D2: WO 9941592 A1 (HANS GORAN EVALD MARTIN) 19 Aug. 1999

D3: US 5973326 A (MICHAEL P., CHELMSFORD; ALAN M. D., MALDON) 26 Oct. 1999

D4: US 5170064 A (ATOMIC ENERGY OF CANADA LIMITED) 8 Dec. 1992

D5: US 5116120 A (VOLKSWAGEN AG) 26 May 1992

D6: US 4189236 A (COLULTER ELECTRONICS, INC.) 19 Feb. 1980

2. Regarding Novelty

D1 is considered to be the most relevant state of the art.

The common technical feature of claims 1, 11, 16, and 24 is that two opposing concave mirrors are used to form an optical cavity. Said claims differ from D1 in that they use two mirrors, whereas D1 uses three opposing concave light reflecting wall-parts (11, 12, and 13). Therefore, the subject matter of claims 1, 11, 16 and 24 is considered to be new (Art. 33(2) PCT).

The subject matter of claims 2-10, 12-15, 17, 19-23, and 25 which are dependent claims is also considered to be new (Art. 33(2) PCT).

3. Regarding Inventive Step

3.1 Concerning Claims 1-10

The subject matter of claim 1 is an optical gas sensor comprising a gas chamber, a gas opening, an optical source and an infrared sensor. The optical gas sensor of claim 1 is characterized in that the curvature of the opposing concave mirrors are designed for the incident light to be parallel to the axis or to pass through the focus.

(Continued on Supplemental Sheet.)

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

Continuation of:

Box V.

The subject matter of D1 is an optical gas sensor which belongs to the same technical field as the present invention. D1 comprises a gas cell (1), openings (6 and 7), a light source (2a) and wall parts (11, 12, 13). Both D1 and claim 1 comprise openings, an optical source, and a sensor, and the gas cell of D1 corresponds to the gas chamber of claim 1.

There are two technical differences between claim 1 and D1: 1) claim 1 comprises two concave mirrors, whereas D1 comprises three concave reflecting mirrors; and claim 1 includes parallel light paths, whereas D1 does not.

The parallel light paths of claim 1 would not be obvious from D1 (see fig. 8), because D1 does not teach or fairly suggest said feature. Therefore, the subject matter of claim 1 seems to involve an inventive step (Art. 33(3) PCT).

Dependent claims 2-10 referring to claim 1 are also considered to involve an inventive step (Art. 33(3) PCT).

3.2 Concerning Claims 11-15

The technical feature of claim 11 that "each of the concave mirrors has the shape of a portion of a parabola or a circular arc" would not be obvious from D1 because D1 does not teach or fairly suggest said feature. Therefore, the subject matter of claim 11 seems to involve an inventive step (Art. 33(3) PCT).

Dependent claims 12-15 referring to claim 11 are also considered to involve an inventive step (Art. 33(3) PCT).

3.3 Concerning Claims 16-17, 19-25

The technical features of claims 16 and 24 that "the cross section of the concave mirror is a circular arc," and "the two circular arcs have different radius from each other" would not be obvious from D1 because D1 does not teach or fairly suggest said features. Therefore, the subject matter of claims 16 and 24 seems to involve an inventive step (Art. 33(3) PCT).

Dependent claims 17 and 19-23 referring to claim 16 and dependent claim 25 referring to claim 24 are also considered to involve an inventive step (Art. 33(3) PCT).

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However, since it is difficult to produce such a system and a step motor is needed for the rotation of the reflective mirror, it cannot be easily used in a small, portable and easy-to-use gas analyzer.

Still another method was disclosed in PCT/SE97/01366 (WO 98/09152) titled
5 "GAS SENSOR" proposed by Martin. In order to provide a relatively long optical path in an optical cavity having a limited size, the method arranges three concave mirror surfaces as illustrated in Fig. 4. In other words, the gas sensor proposed by Martin comprises three elliptical concave surfaces, and it has an optical gas sensor cell structure, employing the White's cell concept of setting the focus of reflected light from each concave surface on or
10 adjacent to the opposite reflection surface.

However, this gas sensor cell having three reflection surfaces is complex. Also, since the incident light, which is radiated from an optical source located on the surface of a main mirror (a mirror of one body) through an optical cavity, may have slight changes in its incident angle, it was difficult to determine the appropriate location of optical sensor.

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There are four kinds of optical cavities that have been applied to existing NDIR gas sensor systems.

First, as disclosed in U.S. Patent No. 5,444,249 of Jacob Y. Wong, which was issued on August 22, 1995, there is a square type or a cylindrical tube type having one
5 infrared (IR) source and one light detector.

Next, as disclosed in U.S. Patent No. 6,067,840 invented by Mahesan Chelvayohan and issued on May 30, 2000 or as disclosed in the Article titled "An implementation of NDIR type CO₂ gas sample chamber and measuring hardware for capnograph system in consideration of time response characteristics" in *Journal of Korean*
10 *Sensor Society*, vol. 5, no.5, pp. 279-285, 2001 by I.Y.Park, *et al.*, there is a type comprising one light detector and two IR optical sources for thermal aging compensation.

Third, what is disclosed in the Article titled "CO₂/H₂O Gas Sensor Using Tunable Fabry-Perot Filter with Wide Wavelength Range" in the IEEE International Conference on

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MEMS, pp. 319-322, 2003 by Makoto Noro, *et al.* is a type using a cylindrical tube optical cavity and applying a Fabry-Perot filter for selecting target gas wavelength.

Fourth, what is disclosed in PCT/SE97/01366 (WO 98/09152) titled "Gas Sensor" dated March 5, 1998 by Martin Hans, *et al.* is a type comprising three concave mirrors in
5 order to increase the light path within a chamber of a small volume.

Detailed Description of the Invention

The present invention has been conceived in order to resolve the aforesaid
10 problems. The object of the present invention is to maximize the length of the optical path and to provide an optical gas sensor having a broad measurement ranges with an optical cavity (or a gas chamber) structure that can be easily designed.

Also, the present invention provides a new optical cavity structure for a new
optical gas sensor cell, and presents a new gas sensor based on the CO₂ concentration
15 measurement experiment result of a sensor employing such an optical cavity.

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Fig. 12 is a perspective view of the optical gas sensor reviewed in the above Figs. 8-11 according to one embodiment of the present invention.

Fig. 13 is a top plane view of an optical gas sensor according to another embodiment of the present invention. Fig. 14 is a sectional view of A-A' of the optical gas sensor illustrated in Fig. 13.

The structure of the optical gas sensor illustrated in Fig. 13 is nearly the same as that of the optical gas sensor of the above Figs. 8-12 except that two mirrors forming a gas chamber wall are configured as parabolas instead of circular arcs.

In other words, the gas chamber wall of the optical gas sensor illustrated in Fig. 13 uses two opposing parabolic reflective mirrors having a common focus but different focal distance. Also, a gas vent (45) is curved in the direction of gravity to prevent internal pollution of the gas chamber.

Upon reviewing the operation principle of the optical gas sensor illustrated in Figs. 13 and 14, infrared light radiated through an infrared lamp (95) passes via an optical outlet (85) and a parabolic mirror (55), and is entered into the gas chamber.

The incident light is entered toward the common focus of a first parabolic reflective mirror (25) and a second parabolic reflective mirror (35), reflected by the first and second parabolic reflective mirrors (25, 35) and converged. The light intensity is measured at an infrared sensor (65).

Further object of the present invention is to produce an optical cavity for non-

- 19 -

dispersive infrared gas sensor, comprising two concave mirrors which are opposed to each other, of which the section is a circular arc, of which the central point is located on the same axis, and which are optically closed except for an inlet for establishing an optical source, an outlet for establishing a light detector and gas inlet/outlets.

5 Also, further object of the present invention can be achieved by a non-dispersive infrared gas sensor comprising an optical source for irradiating infrared; a light detector for ultimately detecting light from the optical source; an optical cavity which is formed by two opposing concave mirrors of which the cross-section is a circular arc, of which the central point is located on the same axis, and which are optically closed except for the inlet for
10 establishing an optical source and the outlet for establishing a light detector and gas in/outlets; an optical modulating part having a pulse modulation time of 200-600 ms and turn-off time of 2, 2.5 and 3 sec. for controlling the light irradiated from the optical source; and an amplification part for amplifying an electrical signal from the light detector.

Hereinafter, further aspects of the present invention will be further explained with
15 reference to the drawings illustrating another embodiments of the present invention.

Basically, the optical cavity of the present invention is produced by circular arcs. The central point of the two circular arcs exists on the same axis.

Also, the embodiments of the present invention design the central point of each circular arc to be identical with the middle point of the straight line going from one circular
20 arc to the other circular arc (the two centers of two circular arcs exist on the same straight line). The reason thereof is for irradiated light under a certain condition to be able to pass via a certain point on the same straight line (if the feature of a circular arc is applied identically with a parabola, the circular arcs are designed to pass via an identical focus). The reason for endowing this condition is, for example, to ensure the characteristic of a

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discharge of the absorbed heat is not conducted completely and the lifetime of the optical source becomes shortened.

Fig. 26 illustrates changes of the output voltage according to the change of CO₂ gas concentration in the above embodiment of the present invention. It shows normalized output signals of the NDIR sensor module when the CO₂ gas concentration increases between 100-2,000 ppm. The normal output signal exhibits the maximum change when the infrared pulse modulation time is 200 ms. As the modulation time increases between 300-500 ms, the normal output signal is considerably reduced.

Meanwhile, the maximum voltage difference is shown at 500 ms of pulse duration time, but simultaneously the reference voltage slightly increases. The change of the output voltage becomes maximum at 200 ms of pulse duration time, and exhibits 18,000 times of amplification gain. At this time, the turn-off time of the infrared optical source is 3 sec.

Although the present invention has been described with reference to particular embodiments of the NDIR gas sensor and the optical cavity, the description is only an example of the invention's application and should not be taken as limiting the scope of the present invention. Various adaptations and combinations of simulations and the embodiments disclosed are within the scope of the invention as defined by the appended claims.

For example, in order to obtain the parallel light of the present invention, another method of producing a parabolic type mirror in an optical cavity can be employed for production of a cost-effective optical cavity, and the present invention can be implemented using laser source having a predetermined wavelength without the use of the IR lamp from Gilway™.

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5. The optical gas sensor according to claim 2, wherein the gas vent is advantageously curved downward or equipped with a detachable cap.

6. The optical gas sensor according to claim 1, wherein the surface of the concave
5 mirror is plated by or deposited with gold.

7. The optical gas sensor according to claim 2, wherein the gas chamber contains a parabolic reflecting mirror integrally formed with the support plate of the gas chamber adjacent to the infrared optical source formed at the support plate.

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8. The optical gas sensor according to claim 7, wherein a light outlet for projecting at least a part of the infrared light from the infrared optical source is formed on the support plate of the gas chamber.

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9. The optical gas sensor according to claim 7 or 8, wherein the infrared optical source is disposed on the focus of the parabolic mirror.

10. The optical gas sensor according to claim 2, wherein the support plate of the gas chamber is attached with a height compensation structure for compensating the
20 inclination of the support plate due to the height of the infrared optical source.

11. An optical gas sensor comprising a gas chamber for housing a sample gas; a gas opening for injecting the sample gas into the gas chamber or for exhausting the sample gas from the gas chamber; an optical source for projecting light toward the sample gas;

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and an optical sensor for sensing the intensity of the light which has passed through the sample gas, characterized in that:

the wall of the gas chamber is composed of two opposing concave mirrors having different focusing distances but a common focus, and that each of the concave mirrors has a shape of a portion of a parabola or a circular-arc.

12. The optical gas sensor according to claim 11, wherein the gas opening comprise a gas vent located at a certain wall of the gas chamber and a plurality of gas diffusion halls disposed on the lower or upper support plate of the gas chamber.

13. The optical gas sensor according to claim 11 or 12, wherein the plurality of gas diffusion halls are covered by gas filters.

14. The optical gas sensor according to claim 11, wherein the surface of the concave mirror is plated by or deposited with gold.

15. The optical gas sensor according to claim 12, wherein the gas chamber contains a parabolic reflecting mirror formed so that the parabolic reflecting mirror causes the incident light from the infrared source to propagate in parallel with the horizontal support plate of the gas chamber.

16. An optical cavity for a non-dispersive infrared sensor, characterized in that: the optical cavity is formed by two opposing concave mirrors, the cross-section of the concave mirror is a circular arc, the two circular arcs have different radius from each

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other, the central points of the two circular arcs exist on the same axis, and the optical cavity is optically closed except for holes for optical source,

optical detector, gas vent and gas diffusion.

17. The optical cavity according to claim 16, wherein the central point of each circular arc coincides with the middle point of the straight line going from one circular arc
5 to the other circular arc.

18. Cancelled

19. The optical cavity according to claim 16 or 17, wherein the central point of the
10 circular arc having a longer radius exists outside of the circular arc having a shorter radius, and the central point of the circular arc having a shorter radius exists inside of the circular arc having a longer radius.

20. The optical cavity according to claim 19, wherein the optical source and the
15 optical detector are located on a different circular arc, and an incident light from the optical source is irradiated in parallel with the axis on which the central points of the two circular arcs are located, reflected once on each of the circular arc and detected by the optical detector.

21. The optical cavity according to claim 20, wherein the parallel light irradiated
20 from the optical source focuses on the circular arc where the optical detector is located.

22. The optical cavity according to claim 17, wherein the optical source and the

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optical detector are located on the same circular arc, and an incident light from the optical source is reflected odd number of times on each of the circular arc and detected by the optical detector.

- 5 23. The optical cavity according to claim 22, wherein the incident light from the optical source incidents to or adjacent to a center of the optical cavity, repeats convergence and divergence during the plurality of reflections and reaches the optical detector, and wherein the cross-sectional area of the light reaching the circular arc on which the optical detector is located is larger than that of the light irradiated from the optical source.

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24. An optical cavity for a non-dispersive infrared sensor comprising:

an optical source for irradiating infrared light;

an optical detector for ultimately detecting the infrared light from the optical source;

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an optical cavity formed by two opposing concave mirrors, wherein the cross-section of the concave mirror is a circular arc, the two circular arcs have different radius from each other, the central points of the two circular arcs exist on the same axis, and the optical cavity is optically closed except for holes for optical source, optical detector, gas vent and gas diffusion;

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an optical modulating means for controlling the infrared light irradiated from the optical source, wherein the optical modulating means has a pulse modulation time of 200-600 ms and turn-off time of 2 sec., 2.5 sec. and 3 sec.; and

an amplification means for amplifying an electrical signal from the optical detector.